CLAIMS

1. A signal processing apparatus (400;800) comprising:
a demodulator (407;900) arranged to demodulate a received signal, which carries consecutive symbols (a_1,..., a_4) at a symbol rate, wherein the demodulator (407;900) is arranged, based on sample values of the received signal, to calculate an error value (ϕ_m) of a given symbol relative to a decision-directed determination of an expected symbol value ($\hat{\theta}$); and
a phase-shifter (406,409;801;1002,1013) arranged to shift the phase of sampling points in time at which points in time, sample values of the received signal is provided to the demodulator (407;1000);
CHARACTERIZED IN THAT the apparatus (400;900) comprises
a processor (408;601;1000) arranged to evaluate an error metric (τ), at the symbol rate, for a given symbol as a function of the error value (ϕ) and symbol values ($\hat{\theta};\theta$), and to determine whether to shift the phase of the sampling points in time based on further evaluation of the error metric (τ).

2. A signal processing apparatus according to claim 1, CHARACTERIZED IN THAT the error metric (τ) is a function of symbol values ($\hat{\theta}_{m-1};\hat{\theta}_{m+1};\theta_{m-1};\theta_{m+1}$) for symbols preceding and succeeding the given symbol (m).

3. A signal processing apparatus according to claim 1 or 2, CHARACTERIZED IN THAT the error metric (τ) is a function of expected symbol values $\hat{\theta}$.

4. A signal processing apparatus according to any of claims 1-3, CHARACTERIZED IN THAT the demodulator (407;900) is configured as a Phase Shift Keying (PSK) demodulator or a Differential Phase Shift Keying (DPSK) demodulator.

5. A signal processing apparatus according to any of claims 1-4, CHARACTERIZED IN THAT the error metric (τ) is a function of the phase

error value (ϕ_m) of a given symbol relative to the decision-directed determination of an expected symbol phase value ($\hat{\theta}_m$), the phase value of a previous symbol (θ_{m-1}), and the phase of a succeeding symbol (θ_{m+1}).

6. A signal processing apparatus according to any of claims 1-5, CHARACTERIZED IN THAT the error metric (τ) is a function of the phase error (ϕ_m) of the received symbol (m) multiplied by the difference between the phase (θ_{m-1}) of a previous symbol (m-1) and the phase (θ_{m+1}) of a succeeding symbol (m+1).

7. A signal processing apparatus according to any of claims 1-6, CHARACTERIZED IN THAT the error metric (τ) is composed of a first term (τ_m^e) representing that the sampling phase is advanced in time and a second term (τ_m^l) representing that the sampling phase is delayed in time relative to an optimal sampling phase (τ).

8. A signal processing apparatus according to any of claims 1-7, CHARACTERIZED IN THAT the first term (τ_m^e) is the phase error (ϕ) of the received symbol (m) multiplied by the phase (θ) of the succeeding symbol (m+1), and the second term τ_m^l is the phase error (ϕ) of the received symbol (m) multiplied by the phase (θ) of the preceding symbol (m-1).

9. A signal processing apparatus according to any of claims 1-8, CHARACTERIZED IN THAT the demodulator (407;900) is arranged to calculate a variable (τ^{tt}) for time tracking based on an accumulated sum of the error metric (τ).

10. A signal processing apparatus according to any of claims 1-9, CHARACTERIZED IN that the processor (408;601;1000) is arranged to determine whether to shift the phase, based on the accumulated sum (τ^{tt}) of the error metric.

11. A signal processing apparatus according to any of claims 1-10, CHARACTERIZED IN that the error metric (τ) expresses Inter Symbol Interference based on an estimate, which is based on an estimated impulse response for a transmission channel (103) over which the symbol is transmitted prior to being input to the signal processing apparatus (800).

12. A signal processing apparatus according to any of claims 1-11, CHARACTERIZED IN THAT the apparatus comprises a sampler (405,404) arranged to sample the signal at an over sampling ratio OSR, which provides OSR samples per symbol; and that the phase-shifter (406,409) is arranged to control which out of every N samples that is to be provided to the demodulator (107).

13. A signal processing apparatus according to any of claims 1-12, CHARACTERIZED IN THAT the demodulator (407;900) is arranged to calculate the error value (ϕ_m) of a given symbol additionally, relative to a reference value (ψ), wherein the reference value is calculated, based on a calculated error value (ϕ_{m-1}) of previously received symbols.

14. A mobile telephone CHARACTERIZED IN comprising a signal processing apparatus (800) as set forth in any of the claims 1-13.

15. A method of processing a signal, comprising the steps of:
demodulating a received signal, which carries consecutive symbols (a_1,..., a_4) at a symbol rate, and based on sample values of the received signal, calculate an error value (ϕ_m) of a given symbol relative to a decision-directed determination of an expected symbol value ($\hat{\theta}$); and
shifting the phase of sampling points in time;
CHARACTERIZED IN further comprising the step of
evaluating an error metric (τ), at the symbol rate, for a given symbol as a function of the error value (ϕ) and symbol values ($\hat{\theta};\theta$), and to determine whether to shift the phase of the sampling points in time based on further evaluation of the error metric (τ).

16. A method of processing a signal according to claim 15, CHARACTERIZED IN THAT the error metric (τ) is a function of symbol values ($\hat{\theta}_{m-1};\hat{\theta}_{m+1};\theta_{m-1};\theta_{m+1}$) for symbols preceding and succeeding the given symbol (m).

17. A method of processing a signal according to claim 15 or 16, CHARACTERIZED IN THAT the error metric (τ) is a function of expected symbol values $\hat{\theta}$.

18. A method of processing a signal according to any of claims 15-17, CHARACTERIZED IN THAT the demodulation is Phase Shift Keying (PSK) demodulation or Differential Phase Shift Keying (DPSK) demodulation.

19. A method of processing a signal according to any of claims 15-18, CHARACTERIZED IN THAT the error metric (τ) is a function of the phase error value (ϕ_m) of a given symbol relative to the decision-directed determination of an expected symbol phase value ($\hat{\theta}_m$), the phase value of a previous symbol (θ_{m-1}), and the phase of a succeeding symbol (θ_{m+1}).

20. A method of processing a signal according to any of claims 15-19, CHARACTERIZED IN THAT the error metric (τ) is a function of the phase error (ϕ_m) of the received symbol (m) multiplied by the difference between the phase (θ_{m-1}) of a previous symbol (m-1) and the phase (θ_{m+1}) of a succeeding symbol (m+1).

21. A method of processing a signal according to any of claims 15-20, CHARACTERIZED IN THAT the error metric (τ) is composed of a first term (τ_m^e) representing that the sampling phase is advanced in time and a second term (τ_m^l) representing that the sampling phase is delayed in time relative to an optimal sampling phase (τ).

22. A method of processing a signal according to any of claims 15-21, CHARACTERIZED IN THAT the first term (τ_m^e) is the phase error (ϕ) of the received symbol (m) multiplied by the phase (θ) of the succeeding symbol (m+1), and the second term τ_m^l is the phase error (ϕ) of the received symbol (m) multiplied by the phase (θ) of the preceding symbol (m-1).

23. A method of processing a signal according to any of claims 15-22, CHARACTERIZED IN THAT the demodulation comprises calculation of a variable (τ^{tot}) for time tracking based on an accumulated sum of the error metric (τ).

24. A method of processing a signal according to any of claims 15-23, CHARACTERIZED IN THAT the evaluation comprises determination of whether to shift the phase, based on the accumulated sum (τ^{tot}) of the error metric.

25. A method of processing a signal according to any of claims 15-24, CHARACTERIZED IN THAT the error metric (τ) expresses Inter Symbol Interference based on an estimate, which is based on an estimated impulse response for a transmission channel (103) over which the symbol is transmitted prior to being received.

26. A method of processing a signal according to any of claims 15-25, CHARACTERIZED IN further comprising the step of sampling the signal at an over sampling ratio OSR, which provides OSR samples per symbol; and that the step of shifting the phase involves controlling which out of every N samples that is to be provided for demodulation.

27. A method of processing a signal according to any of claims 15-26, CHARACTERIZED IN THAT the reference value is calculated, based on a calculated error value (ϕ_{m-1}) of previously received symbols.